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ABSTRACT

Approved in 1979, the robotics technician training program at Macomb County Community College (MCC) in Warren (Michigan) provides students with training in hydraulics and electronics as well as with hands-on training in the area of robotics. Furthermore, the program faculty includes individuals with work experience in electronics, fluid power, and robotics, as well as a number of adjunct faculty drawn from the local industrial community. Because MCC is an open door institution, the background of students enrolled in robotics courses ranges from those without a high school diploma to those with masters' degrees. Included among the skill areas addressed by courses in the robotics curriculum are the following: (1) electronics, pneumatics, hydraulics, and mechanics; (2) robotics; and (3) basic skills (English, math, and physics). Because the college maintains contact with a large number of vendors and users of industrial robots, it has managed to place program graduates in positions in the sales and installation of robots, robot maintenance, customer service, testing, and manufacturing. Program completers at MCC meet the certification standards of a number of organizations, including the Society of Mechanical Engineers/Robotics International, The Robotics Institute of America, and the American Fluid Power Association. (MN)

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ROBOTICS TECHNICIAN TRAINING at MACOMB COMMUNITY COLLEGE

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Industrial robots have been used in experimental manufacturing applications for over twenty-five years. However, this aspect of flexible automation did not receive serious consideration by American industry until the late 1970's. Growth in the 1980's and 1990's is projected to be explosive as a result of increased applications and the development of more sophisticated robots. The number of units in place in 1991 is expected to reach 100,000 compared with approximately 7,000 today.

There are some who refer to the use of these devices as a second industrial revolution that will far exceed the first in its impact on mankind. The robot, it is felt, has the capacity to change most aspects of how we live and work.

As labor costs increase and productivity gains become more difficult to achieve, it is clear that a reindustrialization of the United States will be accomplished through the greater application of automation, computerization and robotization (robots do not need breaks, vacations, sleep, get ill or bored and can work in job situations that are hot, dirty, noisy, contain radiation hazards or are considered unsafe for humans).

Increasingly, manufacturers are turning to robots to achieve production gains and improve product quality. This, in turn, is creating a demand

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for engineers, designers, technicians and workers who understand the application and maintenance of robots. Fully informed and knowledgeable skilled tradespeople and equally skilled and trained technicians and engineers for all aspects of implementation and maintenance will be needed.

The word "Robot" comes from a Czech word for forced labor. Credit for its introduction is generally given to Karel Capek who popularized it in a 1921 play entitled, "Rossums Universal Robots."

The basic function of a robot is to do the work of humans--and to do this it requires a guide and something to guide. The robot guide is a computer/microprocessor; the something to guide is an arm and/or fingers or grippers.

The "Robot Institute of America" provides this definition of a robot:

> "A Robot is a reprogrammable multi-functional manipulator designed to move material, parts, tools or specialized devices, through variable programmed motions for the performance of a variety of tasks."

The key words that separate this type of device from other mechanical ones are reprogrammable and multifunctional. This allows for much greater usefulness since the functions of the computer controlled mechanical arm can be changed or modified by a change in the instructions without a change in the device itself.

Almost half of the robots in use today, in this country, are in the automotive industry, performing functions from welding to painting cars. In other industries, they are used to assemble refrigerators, drill aircraft wings, mine coal and wash windows. Development projects are underway to utilize them to do a variety of different tasks, including crop spraying with pesticides and repair of satellites in space.

ADVISORY COMMITTEE

Macomb Community College is located in the northeast section of the area surrounding Metropolitan Detroit. With an enrollment of over 30,000 students, it is the largest of the 29 public community colleges in Michigan. Over half of the students are enrolled in an occupational program. Our primary service delivery area is Macomb county, which, of the counties in this area, is the one most heavily dependent on the automotive industry. The auto industry is currently the largest user of robots and is expected to continue as the leader for the foreseeable future. Principally, through our Applied Tech Department, Macomb College has developed a strong relationship with the automotive industry and its surrounding supplier companies.

Prior to the introduction of any course work in Robotics, college personnel worked very closely with various segments of local industry.

The Robotics program at Macomb Community College was developed by building upon a strong Applied Technology Electro-Mechanical certificate program. This program received approval from the State of Michigan Vocational Education Department in 1979.

Advisory committee meetings included representatives from the automotive and its supportive industries, from manufacturers of robots, tool and machine companies, a representative from the Robotics section of the Society of Manufacturing Engineers, as well as educators.

These meetings began in 1978, long before the first courses were offered. Both formal and informal meetings were held. Some were held at the college and others were held on job sites. All aspects of training--specific program objectives, individual course modules, as well as equipment suited for the most comprehensive hands-on experiences were reviewed.

Discussions were held with vendors and users , to ensure that the equipment eventually purchased would be representative of state of the art technology, as well as provide a good cross-section of actual robotic devices found in the field. The equipment also had to relate to specific course objectives. Before purchasing any equipment, the advisory committee was asked to review our proposals and to make suggestions for modification.

A continuing active relationship with the advisory committee is necessary to ensure that both course modules and equipment used remain current with the development within this rapidly changing industry.

EQUIPMENT & FACILITIES

Equipment to support this training falls into two broad categories:

1) that which is needed for hydraulic and electronic courses, both basic and advanced, and
2) specific items needed to provide hands-on training in the area of robotics.

Macomb Community College has long offered strong programs in Electronics and in Fluid Power Technology. As a result, the college has a number of well equipped laboratories for training students in these fields. A significant investment is made regularly to maintain state of the art technology in these programs.

Equipment acquired by the college to meet the additional needs in the Robotics program included programmable controllers as well as robots. College research concluded that there were three different vendor company's programmable controllers in various levels of use in industry. In 1979, the College purchased one controller from each of the three manufacturers. Additional units have been acquired from these same companies.

In addition to the controllers, the College, in 1980, acquired robots from three different manufacturers. Prices ranged from several thousand dollars for a "pick & place" type to a sophisticated programmable unit, which cost over $70,000. (Individual robots can cost as much as $150,000 and are available from over 50 different American manufacturers).

In 1982, the College obtained an additional robot and micro-computer package, three separate micro-computers and a demonstration device with multiple arms. As a result, the College now trains students on equipment representing a wide cross section of the different types of programmable controllers and robots found in general use in local industries.

As the industry changes emphasis from hydraulics to electronics, the curriculum will require modification. As the equipment becomes more sophisticated (intelligent in visual and sensing ability), the program will also be adjusted to ensure that graduates continue to receive training employing the latest technology.

FACULTY

All faculty employed to teach vocational courses at Macomb Community College have work experience in the subject being taught as well as the necessary academic qualifications. Thus, the instructor is able to relate actual work experiences to the textbook. The result provides the student with an additional dimension and understanding that is not available solely from the textbook.

Faculty teaching courses in the Robotics Technology Program are no exception. The full-time staff includes nine individuals teaching courses in electronics, fluid power and robotics. The full-time staff is supplemented by a large number of adjunct faculty drawn from the local industrial community. The College strives to maintain a strong

part-time staff in proportion to the full-time faculty. In this manner, the student receives maximum benefit in technical fields of study.

ADMISSION & RECRUITMENT

As an open door educational institution, Macomb Community College does not require high school graduation for admission. However, the vast majority do have a high school diploma. There are also large numbers in attendance who have years of college work including many who already possess a bachelors or higher degree.

As a result, the background of students enrolled in Robotics courses at the college range from those without high school completion to those with masters degrees. There are those who have never been employed in the industrial field as well as engineers from local automotive companies. Enrollment in the Robotics program has progressed in incremental stages. The first students taking courses in Robotics were individuals recruited directly from industry through our Applied Technology Department. This department maintains an active relationship with several hundred industrial concerns. It provides the related classroom instruction required for industrial apprentices and training for the upgrading of journeymen. The first group of students have now completed the program and a number are now active in the installation and maintenance of this type of equipment.

Beginning with the summer of 1980, the College began offering Robotics training to students who, while not necessarily engaged in an apprentice or journeyman position, had completed basic course work in either hydraulics or electronics. They were required to first take course work in either area (hydraulics or electronics) that they had not studied earlier. At the completion of both basic areas of study, the student was eligible to elect specific courses in Robotics.

Finally, in 1982, the college opened the program to students with no previous experience or training in either area, including recent high school graduates.

There are over 1,000 students in some level of Robotics training at M. C. C. Classes are offered from 7:00 a. m. to midnight five days a week and from 8:00 a. m. to 6:00 p. m. on Saturdays.

At each stage of development, the college carefully reviewed results of earlier efforts. Changes were made, both within specific courses and in the total program. For example, earlier students were required to have only a minimal math level competency. In stages, prerequisite courses in Math were included and then increased in level of difficulty, as it was determined that higher levels of proficiency were necessary for success in the Robotics courses. College level physics was added as a prerequisite to election of certain Robotics courses.

It is anticipated that a prerequisite level of proficiency in Math and in reading will be required before future students will be eligible to elect courses in this program. Admission requirements to the program will be introduced. Further, it is anticipated that admission to the Robotics Technology program may eventually become selective and limited.

While criteria and requirements appear to be in the future for electing courses in Robotics, the policy of open entry to the College will be continued. This provides the opportunity for students with deficiencies in Math/Reading, or any other area, to obtain the necessary basic skill development at the College prior to or concurrent with enrollment in other college courses.

Individuals seeking employment in the automotive and related industries will find many fewer jobs in the foreseeable future that will not require

greater mental involvement. There will be fewer jobs in these industries where physical effort or ability will be a primary consideration.

The basic skill level of significant numbers of those recently unemployed as a result of technological change is very low. Before they can retrain in this technological field, with the hope of continued future employment, they require an upgrading of basic reading, writing and math skills. This College, as are many other Michigan community colleges, has developed a Basic Skill component to assess and plan programs for these students on an individual basis.

CURRICULUM

The Robotics curriculum at Macomb Community College, which has been developed over the past several years, is a two-year Associate Degree program which, (1) provides education and training in electronics, pneumatics, hydraulics and mechanics. Skill development in these areas include:

- controls/logic/applications
- pumps and compressors and fluid power circuits
- logic control systems
- drives and linkages
- electronic circuits/microprocessors/controllers & Robotic systems

(2) includes specific courses in Robotics which are built upon these four knowledge areas or disciplines and (3) requires a core of general education courses, including English/Math/Physics.

It is designed to maximize employment opportunities for program graduates both immediately and over the course of their work career. It is designed to train technicians by providing skill training and knowledge which prepare the individual for a wide variety of robot related jobs. These jobs include opportunities as installers, repair and maintenance,

programmers, as well as design & application technicians.

It is a dynamic and flexible program that has undergone numerous changes and refinements to date and will continue to change in response to changing technological needs of industry and our students. It will require continued close contact with industry and contributions from an active advisory committee. Input will continue to be solicited from users as well as manufacturers of robots.

The curriculum will be modified over time to ensure currency of training. Changes will soon be forthcoming to reflect market changes by increasing modules in Electronics and reducing the number in Fluid Power.

Additionally, many of the early program completers are indicating a need to include courses in supervision and management. This need will increase for the foreseeable future as early individuals employed in this industry have opportunities to enter management as the number of robots in use continues to increase.

PLACEMENT

The first robot program completers at M. C. C. were primarily industrially employed individuals who enrolled to upgrade skills required to service equipment already installed or soon to be installed at their company.

This is a field where females as well as males have completed the program and are now employed as a result of this training.

A large number of companies, both vendors and users, maintain contact with the College interviewing graduates and potential graduates. They anticipate a need for larger numbers of trained individuals as the economy picks up.

There are 19 firms located in Michigan manufacturing robots. Ten of them are located in Southeastern Michigan, as is the home of General

Motors, Ford, Chrysler, American Motors & VW of America.

These firms will continue to provide the largest market for program graduates. A recent call for technicians by General Motors resulted in four of the five positions going to Macomb College program completers. There were hundreds of applicants for those five positions.

Job opportunities exist in the sales and installation of robots, as well as in maintenance. Job opportunities also exist in customer service, testing, manufacturing, research and development.

A recent study done by The Robotics International projects 500,000 jobs in Robotics by 1985, with a growing demand reaching 1.5 million by 1990. Currently, there are only a few thousand individuals employed in this industry. Sales in 1991 are expected to reach over 2 billion dollars, compared with 200 million today.

One of the strengths of the Robotics program design at Macomb Community College is that it builds knowledge and skill levels in a number of areas (hydraulics, electronics, pneumatics and mechanics). Graduates will have a solid foundation providing multiple employment opportunities. Additionally, the strong background in several disciplines will provide a foundation for continued training in these areas as the technology in that area changes. This type of program design is anticipated to reduce the chances for future individual unemployment by increasing skills in more than one area and by ensuring basic skill development. This will enable the individual to transfer between the areas to take advantage of job opportunities as they occur.

CERTIFICATION

Program completers at M. C. C. meet the certification standards in a number of areas. This includes certificates by such organizations as The Society of Mechanical Engineers/Robotics International, Robotics Institute of America and American Fluid Power Association.

The Robotics International Association has recently instituted a formal certification program for engineers and technologists in the field to raise and maintain professional standards in the field of Robotics.

There are two different areas for certification, each with its own requirements:

(1) Certification as a Manufacturing Engineer

(2) Certification as a Manufacturing Technologist

ROBOT OF 1990

A few years ago the Robot was a transfer device--a machine which picked up objects at one point and moved them to another location. Today's robots perform a wide variety of tasks including heavy lifting, die casting, welding and spray painting. Today they have the capacity to learn and remember a variety of work related motions and to see well enough to perform simple inspections.

In 1976, this was an industry with sales in the 10-15 million dollar range. In 1982, sales had grown to over 200 million in a very depressed economic climate. During the next ten years, there is expected to be an orderly transition from current predominance of fixed routine robots to "intelligent" ones. Almost 3/4's of all robots on the market in 1990 are projected to be equipped with a computer. Twenty percent will be making logical decisions in real time in response to inputs received from visual or tactile sensors.

New uses for the robot will be found as it becomes more "intelligent." Future robot development frontiers lie in better vision, mobility and increased sensitivity to small changes.

It is projected that one half of all assembly operations in 1990 will incorporate Robot Technology compared to 5% today. The automotive industry and heavy manufacturing will continue to employ the largest

number of robots, but robots will be found performing many other jobs in other areas. Results of greater use of robots include safer and cleaner work places, improved job quality, reduced energy costs and increased worker productivity. The ability of American companies to integrate robots will depend in a larger part on the availability of trained work force to service and maintain them.

EJL:cp
Jan. 18, 1983

ROBOTIC TECHNOLOGY CURRICULUM

		Contact Hours	Credits
First Semester			
FPT 100	Fluid Power Fundamentals	4	3
FPT 101	Pneumatic Fundamentals	4	3
ATE 130	Electric Theory-Electrical Equip. & Intro. to Machine Circuits	2	2
MCR 101	Metrology	4	3
ENG 118	Communications I	4	4
			15
Second Semester			
FPT 112	Fluid Power Circuits	4	3
FPT 239	Pneumatic Circuits	4	3
MTH 145	Algebra and Trigonometry	4	4
EST 171	Basic Electrical/Electronic Service	4	3
EST 172	Robotic Electrical/Electronic Service	4	4
			17
Third Semester			
PHY 116	The Physical Universe	6	4
FPT 210	Fluidic Control Systems	4	3
FPT 220	Electro Hydraulic Systems	4	3
ROB 270	Robotics I	3	3
ATE 164	Electrical-Automation Circuits & Intro. to Programmable Controllers-Lab. Experience	3	3
			16
Fourth Semester			
HIS 200	History of Invention & Tech. in America	3	3
ROB 240	Fluid/Mechano Drives & Linkages	4	3
ROB 271	Robotics II	4	3
ATE 266	Electrical-Logics & Programmable Controllers	2	2
ATE 135	Electrical-Mechanical Blueprint Read.	2	2
Elective	Humanities	3	3
			16

Robotics Technology Curriculum
Macomb Community College
An Associate Degree Program

Robotics (3)				
Mechanics (3)	Hydraulics (3)	Pneumatics (2)	Electrical (4)	Electronics (2)
Physics (1)	Math (2)	Communications (1)	History of Technology (1)	
Basic Skill Ability				